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THE B-29

Historical Study No. 192

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THE SUPERFORTRESS

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Air Technical Service Command
Wright Field
Dayton, Ohio

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FOREWORD

This study is a presentation of the Air Technical Service Command B-29 project, a narrative covering the salient features of the engineering, production, supply, maintenance, and training phases of the undertaking together with the key supporting documents which record the landmarks in the evolution of the Superfortress. The raised numbers in the text refer to footnotes in the appendix.

The B-29 project is comprehensible only if one understands the developments that came before it. The engineering techniques and production lessons which grew up around the B-17 and other earlier heavy bombers have been the factors primarily responsible for the B-29. As a result of this long range heritage, no individual or small group of individuals can be credited with the success of the B-29 project. The Superfortress has been a truly cooperative enterprise.

The concept of the very long range bomber reaches back many years into Air Corps history. The design competitions of the nineteen thirties culminating in the B-19 were a most tangible expression of that policy. The B-19 was important not in terms of numbers but as a vehicle for laboratory explorations in the aircraft industry and at Wright Field, where many of the peculiar problems of very long range bombers were probed. Other airplanes such as the pressurized XC-35 were also lineal ancestors of the

B-29. When the Air Corps sought to develop a pressure cabin bomber in the summer of 1938, the Adjutant General declared that there was "no military requirement" for such a bomber, and the Assistant Secretary of War disapproved the project. Despite this active opposition of the War Department itself, Material Division experiments in pressurization were laying the essential engineering groundwork for the B-29.[1]

THE ENGINEERING PHASE

"Hemispheric Defense" was a phrase currently popular in 1939 when the war in Europe began to arouse public opinion in the United States to the dangers of Axis aggression. At Wright Field, a Material Command officer, Captain Donald L. Putt, interpreted a phrase "hemispheric defense" in aggressive terms by drawing up a statement of military characteristics which envisioned a bombardment airplane with greater bomb capacity and longer range than any airplane ever conceived before. Military Characteristics, Air Corps terminology for the detailed statement of tactical mission and desired performance objectives of an airplane type in terms of speed, rate of climb, ceiling, etc., are an important factor in airplane design because they represent the official goal which airplane manufacturers try to accomplish. Furthermore, Captain Putt actually managed to get his military characteristics approved despite the clamor of isolationist feeling which threatened to force Air Corps planning into an unnatural and restrictive scope.[1]

In January 1940 the Material Division circulated a formal Request for Data to which four aircraft manufacturers, Boeing, Lockheed, Douglas, and Consolidated replied with preliminary engineering information and bid data on designs for long range heavy bombardment airplanes in fulfillment of Captain Putt's 1939 statement of military characteristics. The Division was disappointed with the bids because none paid adequate attention to fire control installations, armor plate requirements and leakproof tanks, items

which the European war had shown to be of signal importance. Moreover, none of the bidders attached sufficient attention to delivery requirements; some having been so unrealistic as to predicate their designs upon the use of engines still so highly experimental that they could not hope to be available for use before 1942. The threat of war was increasing, and the Materiel Division wanted more than promises.[2]

The four manufacturers resubmitted their bids with revised emphasis on the critical items, and in May a Board of Officers headed by Colonel O.P. Echols, Chief of the Materiel Command, met to consider the designs for procurement in service test quantities. Boeing, Lockheed, and Douglas were designated competition winners, and the Board recommended that contracts be given to Boeing and Lockheed for wind tunnel models and mockups. The Acting Secretary of War formally approved these contracts 27 June 1940. Boeing's model 345, the leading design in the competition, was given the Air Corps designation XB-29, and Captain Putt, the man who had done so much to make the project possible, was made Project Officer.[3] By the end of August, General Arnold, Chief of the Air Corps, was ready to forward a contract for two XB-29 airplanes at a total of $3,615,095 to the Assistant Secretary of War for formal approval. When the other competition winner, Lockheed, decided to abandon bombardment airplanes to specialize in pursuit types, Major F.O. Carroll, Chief of the Experimental Engineering Section, suggested that the funds made available might well be used in part to increase the existing contracts with Boeing to secure an additional XB-29.[4]

The winning Boeing design, model 345, contemplated an enormous airplane with a wingspan of 141 feet and a fuselage 93 feet long. This airplane was expected to attain a high speed of 382 mph at 25,000 feet over a no-load range of 7225 miles with a total fuel capacity of 8,000 gallons. In addition to a potential gross bomb load of 40,000 pounds, the projected airplane was to mount a 20 mm cannon in the tail and ten caliber .50 machine guns in two upper and two lower turrets, and the tail.

General Echols was anxious to procure more than the two or three experimental models on contract AC-15429, but General Arnold was somewhat hesitant to ask for funds unless the request could be substantiated with some sort of reasonable proof as to the outcome of the experimental contracts. The lengthy delays which had hindered initial deliveries on the B-17 and B-19 gave a certain justification for this hesitancy, but the Material Division pointed out that the B-29 involved few really unique structural problems inasmuch as the B-29 would be similar to the well established Clipper Ship types with their backlog of design experience. Fire control and pressurization, the two entirely new features, were expected to have passed through the design and test stage long before the first B-29 airframe delivery. Moreover, the Division felt that even if the two special features proved inadequate, the Superfortress would still constitute an attractive combat type. The advantages of ordering a service test quantity were emphasized in pointing out that such a contract would move up initial production deliveries by nearly a year.[5]

Since the experimental procurement anticipated the first production item in January 1943, such a step promised to be a substantial gain, but General Arnold decided against the service test procurement because of the pressure of existing bomber production programs and the fact that any additional B-29 procurement would involve a deficiency appropriation.[6] The whole project, save for the three handmade experimental items without production tooling, was deferred for consideration until January 1941, when a new Congress would meet to reconsider the question of new appropriations.

Apart from financial considerations, General Arnold's decision to delay the B-29 project was undoubtedly influenced by a report from Boeing that the project would have to be delayed until production of B-17's had been carried far enough to permit release of experimental engineering personnel and necessary floor space without seriously hampering the National Defense Program production orders. The delay was less grievous than had been expected, however, and Boeing was ready for the Mockup Committee in November 1940, not many days beyond the date originally scheduled.[7]

The Mockup Board, the officers actually responsible for the final decisions prepared within the larger group of the Mockup Committee, consisted of the following men: Colonel Ralph Royce, president, Lieutenant Colonel F.O. Carroll, Major K.L. Kubank, Major P.H. Kramer, and Major L.C. Craigie. After nearly two weeks of deliberation and inspection, the Mockup Board submitted a detailed list of changes to be incorporated in subsequent

Engineering Orders. Despite the pressure of B-17 production, Boeing had managed to provide a very complete and accurate mockup on all major details except the power plant installations which could not be worked out until dummy engines were procured from the manufacturer. Some indication of the elementary stage of development which the mockup represented may be seen in the fact that the decision to select either hydraulic or electric systems for accessory equipment was left up to the manufacturer. In short, as late as January 1941, there were still a great many major design problems to be solved before actual construction could begin on the XB-29.[8]

As the B-29 began to take shape in the Boeing facility, in the Materiel Division there were some who lacked faith in its ultimate success. The unfortunate experience of the experimental B-26 with an unusually high wing loading ratio led to the conclusion that the B-29 might be dangerously heavy for the designed wing area. General Echols ordered an immediate investigation to settle the question once and for all. A committee, including the Materiel Command officers Brigadier General G.C. Kenney, Lieutenant Colonel K.B. Wolfe, Major T.A. Sims, and Major J.S. Griffith, studied the problem in minute detail. Their decision was of paramount importance, for increasing the wing area of the airplane would amount to a major redesign delaying the project for months. The Committee, in a report prepared by Major Sims, shouldered the entire burden of responsibility for the future of the B-29 in recommending that no design change be made.

There were some details of the Superfortress which had not been designed by the time the Mockup Committee gathered, but there were others which had a long history of development reaching back many months before the B-29 project itself. Chief amongst these was the Wright R-3350 engine, an 18-cylinder, air-cooled, double-row, radial engine. As far back as 1935, the Materiel Division had encouraged Wright with experimental development contracts, but, after successfully completing a fifty hour endurance test in 1937, the new engine developed a series of difficulties which had not been completely ironed out when production contracts were let in May 1941 to provide power plants for the B-29 and other four engine bombers.

As late as October 1941 there was but a single R-3350 engine available, and a whole year later there were only thirty. Not until the end of 1943 did production really begin in earnest, but even at that late date there were only some 800 odd engines available to both the Army and the Navy. These production delays must be measured against important engineering accomplishments, however, for the original 1800 hp rating had been increased to 2200 hp by July 1944, and tests revealed potential ratings as high as 3000 hp. Water injection fuel systems gave promise of 2600 hp for War Emergency ratings with 2800 hp as the next objective. When combined Army and Navy requirements threatened to swamp the several Wright facilities, Chrysler was licensed to build R-3350 engines. By 1944 Wright and Chrysler together were manufacturing more than 11,000 engines a year.[9]

Because the B-29 was to be a pressurized cabin airplane, it was necessary to design a completely new armament system to give remote control of strategically located gun turrets from a centrally located gunner's position. The Armament Laboratory at Wright Field negotiated in March 1940 with the Sperry Gyroscope Company to secure a system which would permit a single gunner, using a double ended periscope and ballistic computer unit, to control the fire of five different gun positions. However, when the initial Sperry central station fire control systems were flight tested in a B-17, the results were so discouraging that the Sperry equipment had to be dropped. Fortunately a parallel development using decentralized control had been carried on by General Electric. This system utilized five separate gunners stationed in blisters employing direct sighting rather than periscopic scanning. Because both Sperry and General Electric systems were highly experimental, the Sperry fire control system was continued in production as insurance until tactical experience proved the General Electric system to be adequate.[10]

While the original fire control system design called for two-gun turrets, later production versions appeared with the upper forward turret mounting four guns. Similarly, some of the production airplanes appeared without the 20 mm tail cannon. In the spring of 1945 a radar equipped B-29 capable of accurate bombing in all kinds of weather appeared stripped of nearly all its armament.

The B-29 was designed to carry a 12,000 pound bomb load 2,700 miles or an 8,000 pound bomb load 5,400 miles, but its

unloaded ferrying range reached more than 4,000 miles. This represented a remarkable increase over the B-17, which can carry only 6,000 pounds of bombs for 1,450 miles or a 4,000 pound bomb load 2,350 miles and has a maximum empty ferry range of 3,100 miles. The B-29 is truly a very long range bomber.

Like pressurization and fire control, propellers for the Superfortress posed a difficult problem. Both Curtiss-Wright and Hamilton-Standard perfected new four-bladed propellers for the aircraft, but the novelty of the project made it difficult if not impossible to test the designs adequately until the B-29 actually took to the air. By that time, the summer of 1943, when extensive flight test reports finally began to come in, the production demand for propellers exceeded the limited available capacity. There was little choice between the Curtiss electric and the Hamilton hydraulic versions; each had a number of peculiar advantages in its favor, but since Hamilton offered the greater promise for large scale production, it was decided to select the hydraulic version for the B-29.

Curtiss continued to experiment, however, and produced a reversible pitch propeller to aid braking which contained many features superior to the Hamilton model in use. Propeller braking, that is, the use of reversible pitch propellers enabling the B-29 to shorten its required landing run by a considerable distance, was an exceptionally important development because it permitted B-29's to land on fields originally designed for B-17's and small aircraft. When changes in the B-32 production schedule,

which had previously earmarked Curtiss capacity, made it possible to reconsider Curtiss for B-29 production, there was some agitation to equip the Superfortress with electric propellers. This trend was considerably strengthened by the increasingly frequent number of accident reports from combat theaters, until by the end of 1944 the question was brought to a head. Nevertheless, the continued impracticability of expanding Curtiss production led to the formation of a plan to utilize Hamilton-Standard production capacity in conjunction with the electric control features of Curtiss.[11]

The pressurized cabin, one of the most unique features of the B-29 project, reflected the culmination of a number of years devoted to pressurization research. The Lockheed XC-35, appearing in 1938, pointed the direction to be taken, and tentative specifications for cabin pressurizing systems were prepared by the Material Division in 1939. After the outbreak of war in Europe, General Carroll, Chief of the Experimental Engineering Section, took the initiative in arousing interest in the problem among a few selected concerns with industrial experience in related lines.

In December 1940 General Electric reported that such a large number of enquiries had been received from aircraft manufacturers regarding pressurizing systems that plans were under way to design a standard piece of equipment. Significantly, the Experimental Engineering Section warned General Electric that future specifications would require equipment satisfactory for 35,000 feet or higher. The trend in pressurization was clearly defined even though the working details were not entirely perfected.

While the several manufacturers interested in perfecting pressurizing pumps continued their experimental fabrications, the Experimental Engineering Section continued its research to improve the specifications for pressurizing systems by conducting a series of tests of the effect of bullet holes on supercharged cabins. In August 1941 the Eclipse Aviation Division of the Bendix Corporation planned to supply Boeing with cabin pressurizing equipment. General Electric, the other potential source of pressurizing equipment, seemed more interested in engine turbo-superchargers than cabin systems, so comparatively little progress was made. General Electric was urged to remember that personnel pressurizing requirements began at the same altitude as engine supercharging, but until production plans for the B-29 appeared in earnest, few manufacturers were very anxious to press the development.

The primary difficulty in pressurizing the B-29 grew out of the fact that the accumulated body of experience in the subject was so small. The B-29 project offered the first real challenge to perfect pressurizing equipment on a realistic basis, and as the Superfortress became a reality, the body of knowledge expanded. North American Aviation's XB-28 might have served as an important intermediate step, for it too was pressurized, but when the airplane failed to advance beyond the experimental stage, the entire burden of research and improvement reverted to the B-29.

Eclipse two-stage, engine-driven, centrifugal compressor pressurizing systems were installed on the earliest B-29 off the

production line, but excess weight, repeated mechanical failures and poor production schedules led to consideration of engine turbo-supercharger compression as a more efficient, less complicated means of pressurizing the B-29 cabin. This system, when perfected with electronic control Minneapolis-Honeywell regulators, became standard equipment on the later production models.[12]

Pressurization, turbosuperchargers, specially designed propellers and a complete fire control system were the outstanding achievements of the B-29, but there were hundreds of other less well known but no less spectacular engineering accomplishments. As the number of electrically operated accessories on the B-29 increased, the total current load requirements passed the peak capacity of existing generator equipment and entirely new Superfortress generators had to be designed. In all, more than 125 electric motors were installed in the B-29.

Not every item in the B-29 was of new design. Wherever possible, plans called for existing equipment already proven in combat use. The landing gear assembly offers a specific illustration of this point. The enormous weight of the new airplane threatened to impose shock loads far beyond the capacity of existing tires, and the design as well as production of a new tire promised to bring delays and difficulties. The whole problem was avoided by designing dual landing gear, using twin wheels and tires identical to the B-17 version. However, the retracting motors built by Jack and Heintz and the struts built by Boeing's long time subcontractor A.O. Smith both had to be specially designed for B-29 use.

Beyond these basic design and production achievements, there were countless engineering changes which perfected the initial designs, changes proven necessary by actual flight and combat experience. Some general impression of the importance of these production-phase changes can be seen from the fact that the ratio of engineering man hours devoted to design on the production airplane as contrasted with the experimental airplane was on the order of ten to one. That is, for every hour devoted in engineering the original XB-29 design nearly ten hours were devoted to the various design problems encountered in working out design variations on the production models.[13]

For instance, when a flight to the United Kingdom in February 1944 revealed that the windows of the B-29 fogged dangerously at high altitude, a whole series of improved defrosting devices had to be built into the production airplane. Another example of the changes required by combat appeared in the waist gunners' scanning blisters. Vibration and undue stress concentrations coupled with the pressure differential inside the cabin caused a number of blisters to blow out in flight. This particular problem involved a complete redesign to produce a laminated blister and the fabrication of a new shock-resisting mount.[14]

One of the most important design changes made because of combat necessity was the cowling redesign. The original version proved extremely difficult and time consuming to remove when effecting engine repairs. Accessibility on the ground was as

important as successful operation in the air, for time lost in performing routine engine maintenance is comparable to airplanes lost in combat with the enemy.

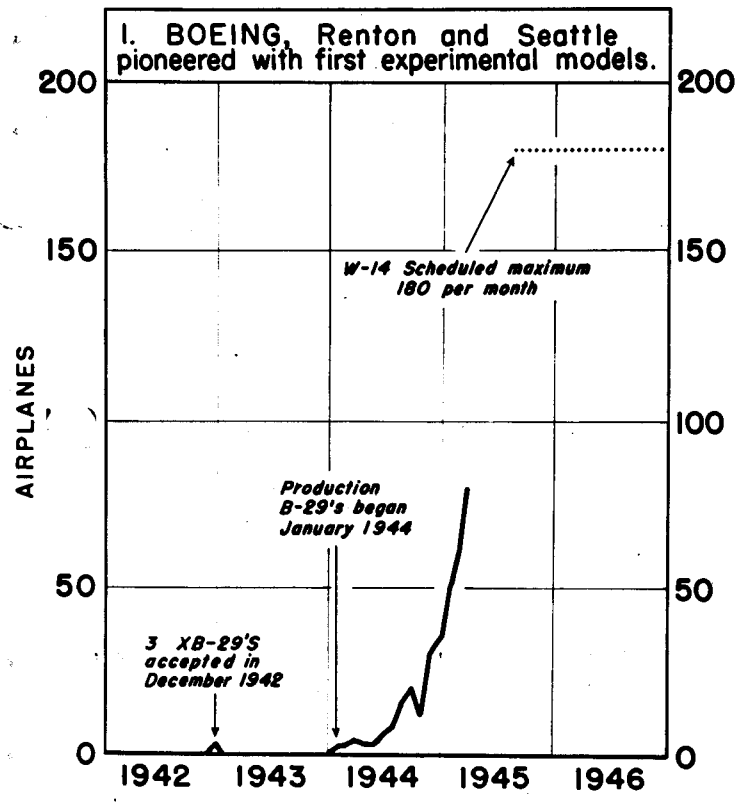
One of the most significant engineering changes of the entire project was begun in August 1944 when a determined campaign was undertaken to reduce the gross weight of the Superfortress. The entire airplane was combed for every possible excess item which might be eliminated to reduce the overall weight, which had gradually been creeping upward as modifications added equipment, reducing the tactical operating radius to a dangerous margin.

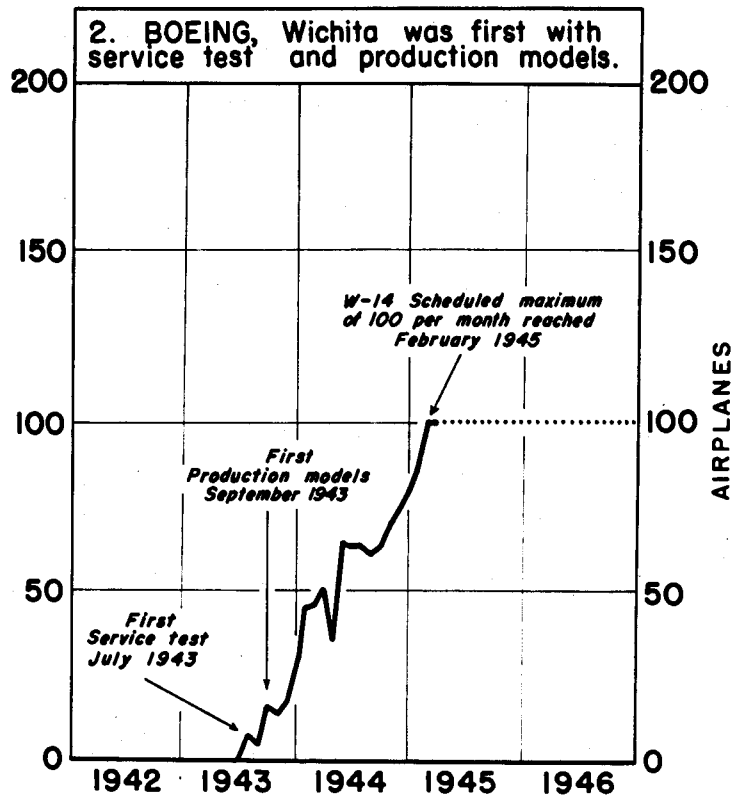
By removing superfluous instruments, extra cameras, auxiliary crew bunks, cabin sound proof lining and by replacing armor plate with flak curtains, to mention but a few changes, it was possible to make a saving of more than 4,000 pounds. Redesign of major components anticipated a total weight saving of better than 13,000 pounds. This resulted in an immediate increase of approximately 450 miles in range with an ultimate anticipated range increase of 1230 miles.[15]

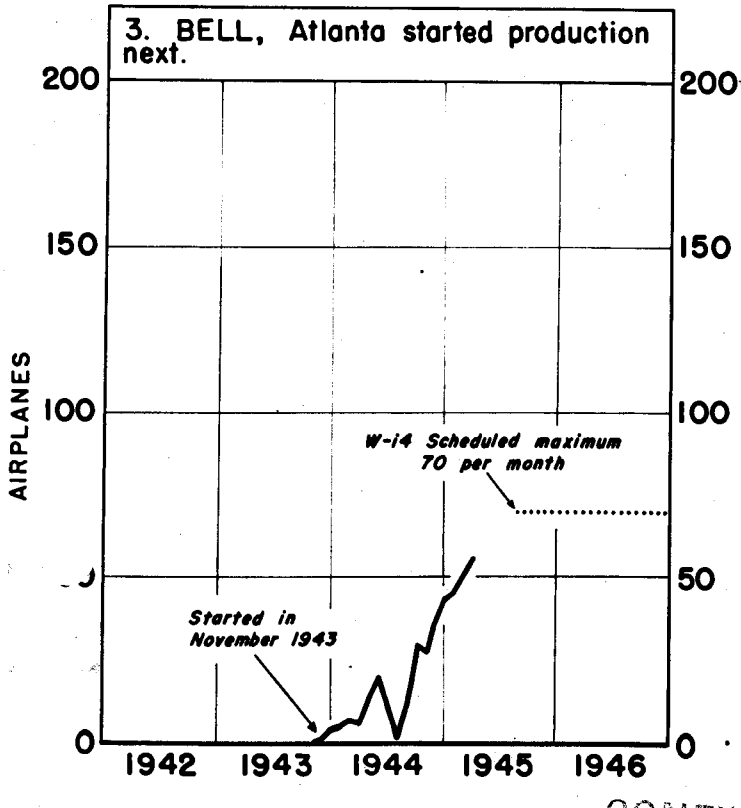
All these changes, design improvements and simplifications to facilitate production or increase the safety factor of the airplane as well as enlarge its scope of tactical performance have at times slowed down the actual rate of production, but the efficacy and importance of the cumulative delays have been amply justified in the increasingly powerful blows which the Superfortress has been able to deliver against the enemy.

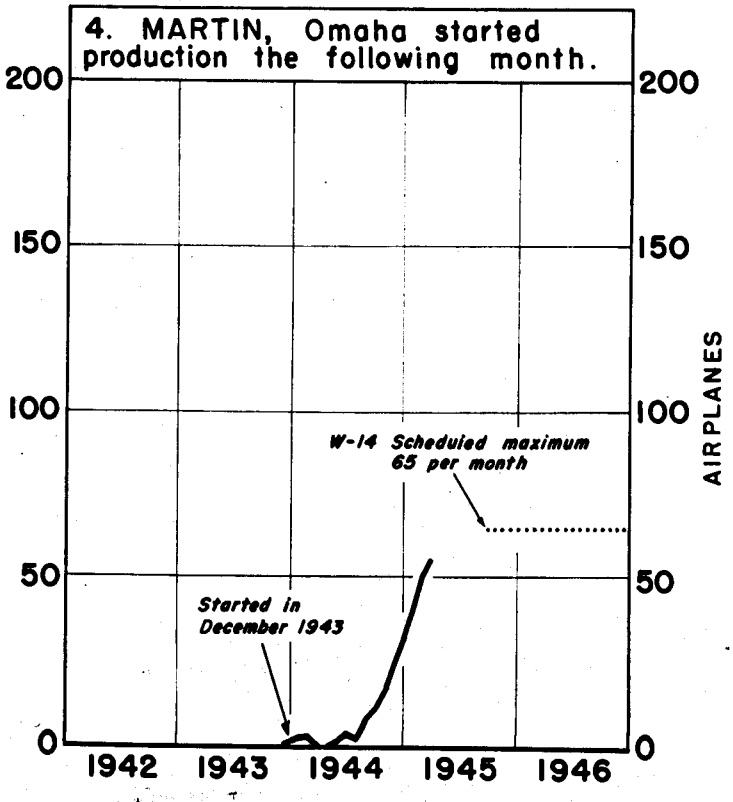
Certain milestones summarize the B-29 project in a few words. The Air Corps design competition for very heavy bombers began in January 1940. Boeing's winning design won its first contract in June. By November the XB-29 mockup was ready for inspection at the Boeing plant. The first XB-29 flew in September 1942, and the first production model B-29 took the air in June 1943. Less than a year later Superfortress squadrons were bombing the Japanese.

GROWTH OF B-29 PRODUCTION









THE PRODUCTION PHASE

When the Material Division first considered the B-29 project in 1940 it was generally believed that the first experimental airplane would fly sometime in 1941. The promptness with which Boeing turned out the original mockup seemed to substantiate this belief, but as the actual work of fabricating the XB-29 progressed, a continual torrent of problems delayed the project so that the initial XB-29 flight did not take place until September 1942.[1] These perpetual delays, the cumulative time consumed in ironing out the series of engineering difficulties which were certain to occur in so novel a project, made production planning difficult to carry out on any large scale before January 1942 when General Echols arranged a meeting in Detroit with Boeing, General Motors, Bell, and North American representatives and Material Division officials.[2]

The Detroit meeting, of 10 February 1942, was a significant landmark in the B-29 project.[3] The general conclusions of the meeting were reduced to concrete form by a sub-committee consisting of Colonel K.B. Wolfe for the Material Division, J.H. Kindelberger of North American Aviation, Fred Collins of Boeing Aircraft, L.D. Bell of Bell Aircraft and T.P. Wright for the War Production Board.

The initial plan called for the organization of four facilities, allocation of contracts, and preparation of a monthly production rate plan according to the following estimates:

Facility	Contract	Rate per Month
Boeing - Wichita	750	50
Bell - Marietta	400	40
North American - Kansas City	300	30
General Motors - Cleveland	200	20

In addition to this basic plan of organization, the Committee prepared an outline of responsibilities for the individual contractors. In addition to the assigned production burden, Boeing was to furnish master guages and detailed tooling drawings to all the other prime contractors. Beyond this, Boeing was made responsible for the functioning of a liaison organization to see that all design changes were properly coordinated with all manufacturers.

The responsibilities of the other contractors varied with their production capabilities. General Motors, Fisher Division, was to arrange for the production of all forgings, castings and stampings required by Bell and North American. Furthermore, Fisher was to provide a source of supply for such complete subassemblies as tail surfaces, flaps, wing tips, and complete engine nacelles. Bell and North American were to build center sections and fuselages and assemble the airplanes in final form.

Experienced Boeing subcontractors such as Briggs and A.O. Smith were to be surveyed to study the possibility of furnishing similar subcontractor services to the new prime contractors. In brief, the B-29 production planners laid the foundation steps for large scale production along rational lines based on the practical experience in airplane production garnered with the B-17 and other heavy bombers.[4] The effectiveness of that experience appeared in the final recommendation of the Detroit group which established

a B-29 liaison committee, formed by representatives of the four prime contractors, the WPB, and the Air Corps, to reduce the statement of principles enunciated at Detroit into detailed practice.

The first meeting of the newly established Liaison Committee under the chairmanship of Brigadier General K.B. Wolfe was held in Seattle, Washington during May, when the process of reduction to detail was well under way.[5] The problems confronting the Committee were far from routine. In the spring of 1942 the country faced an acute machine tool shortage, but even more serious, the Boeing XB-29 was still so far from completion that it proved difficult to provide more than the sketchiest plans for production tooling.[6] The inevitable cost of running experimental and production phases simultaneously had begun to make itself felt.

At the end of April 1942 the B-29 Liaison Committee adopted a formal charter which established an Executive Committee with full power to make decisions, in all save contractual matters, which would be binding on all parties involved in the enterprise. The specific functions of the Committee included coordination of production among contractors, subcontractors and government agencies; reviewing material and machine tool requirements; and designation of Subcommittees to carry out the details of coordination. This final function was a product of necessity for the sheer magnitude of the project was building up a volume of work far beyond the capabilities of a single committee.

Four Subcommittees were accordingly established at once to advise the Executive Committee in its deliberations. The Engineering Subcommittee was to specialize in all problems relating to technical coordination of design changes between the various parties involved, while the Tooling Subcommittee was established to perform a similar coordination in the preparation of production tools. A Procurement Subcommittee was to facilitate production with master material delivery schedules, and a Spare Parts Subcommittee to determine the requirements for spares. Somewhat later, as the actual production phase progressed, the Executive Committee established an Inspection Subcommittee to insure a high standard of uniformity in the inspection techniques of the different contractors.

The first Executive Committee consisted of General Wolfe for the Air Forces, E.C. Walton for WPB, E.F. Fisher for General Motors, P.B. Collins for Boeing, and L.D. Bell for Bell and H.S. Houston for North American, but membership varied considerably in the months that followed, Captain H.L. Webster frequently representing the Air Corps, B.A. Winter representing Bell, and A.P. Ripley for General Motors or more specifically Fisher Body, and F.B. Collins for Boeing. Colonel Denis Mulligan, Colonel L.F. Harmon, Lieutenant Colonel Frank Cook and Lieutenant Colonel W.M. Collins and many others shared in the deliberations of the Committee as various phases of the production problem came into particular focus.

It was these Subcommittees, working in conjunction with the Executive Committee, that hammered out the working details of B-29 production, details such as tooling policies, responsibilities,

and coordination procedures as well as procurement policies and procedures. The different manufacturers used different tooling techniques; Boeing drawings were unfamiliar to Fisher, and the extensive interchange of parts and assemblies among the members of the prime contractor family made frequent meetings for clarification an absolute necessity.

The Executive Committee handled problems of every proportion. They defined terms and interpreted rulings; they outlined procedures and working plans; and of more importance, they actually established the lines of policy to be followed regarding such important matters as facility expansions.

Perhaps no other index gives so accurate a figure of the enormous proportions of the B-29 project as the facilities constructed in preparation for mass-producing the Superfortress. Since all the manufacturers involved built other types of aircraft, it is extremely difficult to determine the exact sums allocated to B-29 facilities, but in general the following figures reveal the proportions of the project.

Facility	Approximate Facility Cost
Boeing - Wichita	28 million
Boeing - Renton	22 million
Boeing - Seattle	.5 million
Bell - Marietta	57 million

These figures do not include the millions devoted to the construction of modification centers, nor do they reckon the facilities built for the manufacturers of major components, such as Fisher, or for the dozens of subcontractors, such as Hudson,

Briggs and Chrysler of Detroit, Goodyear of Akron, and the Murray Corporation of Scranton, all of whom received vast new facilities to share in the B-29 project. The 22 million dollar facility originally built for B-26 production at Martin - Omaha was still another manufacturing source which must be considered in the list of important B-29 manufacturing establishments.[7]

Throughout the spring of 1942 Boeing made every effort to deliver drawings of B-29 production jigs to the contracting group, but the delays of experimental items continued to thwart production planning. Delays in the Boeing plant ramified dangerously throughout the series of contractors and subcontractors because each delay at the point of design origin piled up successive delays for the satellite prime contractors, subcontractors, outside producers, and vendors or suppliers. The Executive Committee had to establish a balance between pressing for production and insuring a successful solution in the numerous engineering problems which appeared as Boeing moved toward completion on the first article.

In July 1942 the Navy released Boeing's Renton facility to the Army. This made it possible to devote North American's capacity to increased B-25 production and to concentrate a larger proportion of B-29 production in Boeing hands. While this simplified the overall problem in reducing the number of new employees that had to be trained in Boeing methods, all manner of readjustments had to be made, new contracts drawn, subcontractors reapportioned, and production schedules for tools, materials, and labor revised.[8]

A year later, in July 1943, when Fisher embarked on the XP-75 project and B-26 production tapered off, Martin - Omaha with its circle of chosen subcontractors, including Chrysler, Goodyear, and Hudson, entered the B-29 production project as a final assembly facility replacing Fisher. Fisher, however, continued to manufacture components such as nacelles as originally planned.[9]

Despite the combined efforts of Air Force and manufacturers personnel, the B-29 project did not advance without mishap. In an undertaking so extensive it was inevitable that misunderstandings would occur, and problems, unpredictable in the planning phase, would suddenly appear to frustrate the hopes of an early delivery for the first production article.

When Boeing-Renton took over the North American contract it was a comparatively simple matter to reach an agreement relative to the absorption of Government Furnished Equipment and other such items on hand, but the task of replacing North American representation on the various Subcommittees raised a vexing problem. Boeing-Wichita and Boeing-Renton represented entirely different facilities even though they were Boeing concerns. The other prime contractors felt that Boeing, with single representation on the several committees despite its dual facilities was not carrying the load and contributing its full share of the talent required.[10] Such administrative problems as these had to be hammered out to the satisfaction of all the parties concerned, and reaching agreement consumed valuable time.

Administrative problems were, however, but a minor reflection of the difficulties encountered in organizing B-29 production. In November 1942 it was discovered that the B-29 was not receiving the "Number-One" priority which had been granted to it, and every precaution had to be taken to insure priorities in spite of pressing competition from current demands for airplanes already in combat.[11]

Early in 1943 as engineering changes began to come in from the extended flight tests of the XB-29, a whole new series of problems appeared. Hitherto, the question had been to line up vendors and subcontractors and secure original Boeing drawings, but as experience in the air dictated revision there were revisions and reconsiderations of existing designs to process. By 1945 more than 1,000 engineering changes had been considered in the B-29 design, and of these between 60% and 70% were actually put into the airplane.[12]

Design changes meant increased difficulties for everyone from prime contractor down to vendor because it often happened that a simple change in one particular assembly affected the design and manufacture of a whole group of adjoining assemblies.[13] Despite the greatest efforts of the Executive Committee and all the coordinating agencies of the Materiel Command it proved impossible to make the products of the several prime contractors completely interchangeable. As late as March 1945 the question of interchangeability was still not entirely solved.[14]

As the large number of industries, contractors, subcontractors and all the rest began to acquire experience in production and a body of trained personnel, quantity production began to make headway. By the late summer of 1943, beginning with one or two airplanes a month and at a rapidly increasing pace, the rate of deliveries continued to grow until the spring of 1945. The appendix to this report demonstrates the scale of this achievement in detail for each manufacturer involved, but the most revealing indication of the cumulative accomplishment of the B-29 project appeared in March 1945 when the 2000th airplane came off the assembly line less than two years after the appearance of the first production model. But long before this cumulative total was reached, the Superfortress program had encountered serious snags. No sooner had quantity production begun than coordination problems appeared.

Every week of delay in deliveries meant a later departure date for the first bombardment wings to leave for combat, and General Arnold was anxious to have the B-29 debut as early as possible. To this end General Wolfe, the Commanding Officer of the 58th Bombardment Wing, the first Superfortress organization, was authorized to take personal responsibility for all changes and revisions to be made in the production airplanes currently coming from the assembly line.[15] General Arnold hoped to freeze the B-29 as far as possible to insure the completion of a fly-away group of 200 airplanes by March 1944, but the production problems encountered in the fabrication of basic components and assemblies were in many cases more serious than the delays entailed by design changes.

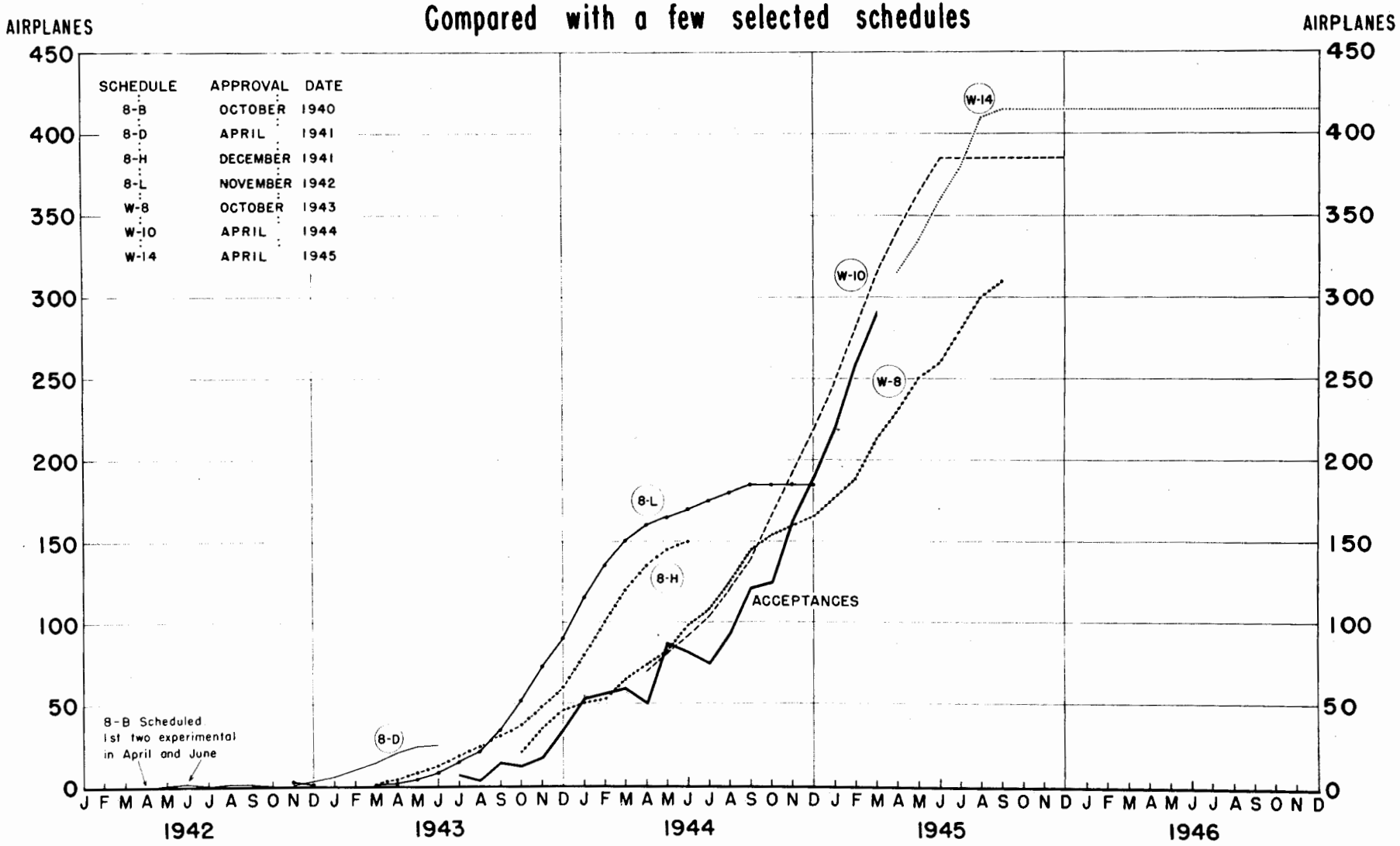
Fisher nacelles, General Electric fire control system computers, propellers, and above all, Wright R-3350 engines were critically behind production scheduling in November 1943.[16] The manufacturers concerned were given every possible encouragement, and General Knudsen guaranteed the cooperation of all the Air Force agencies involved.[17] When stoppages resulted from material shortages or inadequate assembly supply, Materiel Command expediters were assigned to track the critical items through every phase of fabrication from raw material to finished component or part waiting on the line for final incorporation in the assembled airplane. Where individual manufacturers were found to be at fault, all the resources available to the Air Forces were made ready to facilitate production by giving technical advice based on a wide range of production experience.

Every possible means of exerting pressure to increase the production tempo was resorted to, even to the point of taking the entire project "out of channels" until the end of 1943. This step meant that critical decisions were handled on the spot, often verbally, and the normal time-consuming but necessary paper work followed at a more conventional pace.

The combined efforts of the manufacturers and the Air Force personnel engaged in these extraordinary efforts brought real results. The first tactically available airplane departed for India in March 1944, and three months later there were enough Superforts based in India to stage the first B-29 raid 5 June 1944 over Bangkok, a mission performed two weeks less than a year after the first production B-29 left the Boeing-Wichita plant.

B-29 ACCEPTANCES UP TO THE 2000TH AIRPLANE

Compared with a few selected schedules



THE SUPPLY PHASE

While B-29 production began to gather headway, special plans were drafted to organize a system of supply, particularly for spare parts, to insure a high standard of combat efficiency in whatever theater of operations the B-29 was to be called upon to operate. The Spares Subcommittee of the B-29 Executive Committee undertook to solve this problem.

Although the Subcommittee was not officially activated until the spring of 1944, supply planning was begun as early as the fall of 1942. Each of the prime contractors, Boeing - Renton, Boeing - Wichita, Bell - Marietta, and Martin - Omaha were represented on the Subcommittee in addition to the three outstanding subcontractors of Government Furnished Items, Martin - Baltimore, Fisher Body, and Republic Aircraft of Evansville, Indiana; Major G.C. Hahn, B-29 Requirements Officer, Air Technical Service Command, and Major G.W. Hard, B-29 Maintenance and Supply Liaison Officer at Seattle were the two Air Technical Service Command officers most active in the committee's work.[1]

The Subcommittee worked out a simple, functional procedure to accomplish the difficult task of providing spares for such a dynamic thing as an airplane always in a state of flux and change. Provisioning teams were set up by the Air Technical Service Command for each block of airplanes purchased on contract, but the teams operated on the basis of ratios established by the Subcommittee itself.[2]

The actual process of determining the number of replenishment spares to be manufactured for each specific item of equipment was based on two indices. Monthly Consumption Data Reports begun in July 1944 provided accurate statistical replacement rates based on actual experience with early production model airplanes.[3] Supplementing this accurate information and providing an initial point of departure in the preparation of replenishment plans was the experience in other airplanes such as the B-17.

As the Subcommittee determined the requirements for spares, they were included in the basic contract for airplanes. Whenever the original estimate proved inadequate, flexible or "open" contracts were arranged to procure the additional quantities required whether in small quantities for emergency changes or in comparatively large quantities to be used as stock replenishment items.[4]

The task of maintaining adequate stores of B-29 spares wherever needed was enormously complicated by the fact that it proved impossible to achieve an absolute level of uniformity amongst the many manufacturers involved in the project, and, as the engineering changes numbered several hundred, control of spares became an ever more complicated project. One of the most important factors contributing to the successful supply program was the Boeing Spares Document, a Boeing-Seattle Spares Unit project published in conjunction with the B-29 Spares Subcommittee.[5]

The Spares Document provided a single master list of every single spare part in the B-29, and listed the manufacturer and the particular production block, by serial number, by whom the spare had been manufactured.[6] As production advanced and design

changes affected the airplane, the Spares Document was constantly revised and loose leaf sheets forwarded to all interested parties. Such an undertaking soon became a volume costing several hundred dollars for each issue, but so great was its utility in providing the necessary information to keep airplanes in operation that a copy was provided each supply activity and each B-29 tactical squadron and service squadron.[7]

With the activation of the 58th Wing, which was later to expand into the Twentieth Bomber Command, the supply problem entered its active phase. The task was a three fold enterprise: to supply the theater with spare parts before the arrival of the airplanes at their operating bases; to supply training bases and staging areas in the United States; and to establish minor stocks of spare parts along the ferry routes which the Superfortresses were to follow in their journey halfway around the world to the China-Burma-India theater. This final task was complicated by the fact that alternate routes were to be prepared for the ferry journey out.

To insure an adequate supply of spares, a system of preconcurrency was followed, that is, spare parts, instead of being procured concurrently with airplane deliveries were provided weeks and months in advance to provide a margin of time in which to ship the heavy tonnage by water in order to guarantee time for organizing the system of supply before the first airplane left the United States.[8]

In the Air Service Command the 58th Bombardment Wing was designated the PQ project. Headquarters for the Wing were established at the Smoky Hill Army Air Field near Salina, Kansas, where the groups moved for final staging in the fall of 1943. The Supply Division of the Air Service Command set up a special office to handle priority requests for B-29 supplies during this critical period immediately prior to the departure for combat.[9] From May to October Major G.C. Hard had handled special B-29 requests in the Supply Division, but during October 1943 Lieutenant Colonel L.A. Shelton was appointed Project Officer for the undertaking.[10]

By December 1943 overseas shipments for the CBI theater were nearly complete. The achievement represented an amazing amount of detailed work. Air Service Command personnel checked and double-checked every item of every shipment against possible error. Weekly reports to Washington outlined the exact status of each element in the over-all program, and controls were established to be absolutely certain that no airplanes would be delayed for lack of spare parts.

The major supply objective was to get the air echelon off on schedule from the Kansas cornfields. To accomplish this objective, a number of emergency procedures were established. The Sub Depot at Salina was designated as Control Depot for the whole operation, with an Oklahoma City Air Service Command officer assigned to serve as liaison agent with the various Sub-Depots at Salina, Pratt, Walker and Great Bend.[11]

When requests for airframe parts were received at the Salina Control Depot they were ordered directly from the 832nd Specialized Depot at Topeka where Major C.J. Langen was B-29 project officer, while all other parts and accessories were referred by telephone or wire directly to the Oklahoma City Air Technical Service Command. This special treatment was necessary because of the time element. The problem of supply was further complicated by the fact that staging, POM (Preparation for Overseas Movement) and modification activities were all being carried on in conjunction with the training activities in the Kansas area.

To expedite this whole process a special group of Supply Division officers was organized at Headquarters, Air Service Command, to supervise every phase of supply activity. Lieutenant Colonel I.W. Stephenson, General Miller's personal field representative, Lieutenant Colonel J.W. Servaites, Major E.F. Lowry, Major W.W. Moddisette and Major O.W. Hard all travelled to the field installations and personally directed the ordering and shipping of parts for delivery to requisitioning units. The officers made daily visits to Group S-4 and Engineering officers as well as Squadron S-4 and Technical Supply units to check the status of needed parts.

The central office at Salina maintained a record of all operations and established close liaison with Air Service Command Headquarters and the individual operating bases. Daily telephone calls made it possible to keep an accurate check on the status of all shipments and shipping instructions, while a

careful system of follow-ups on air shipments made certain that there would be no serious shortages in the supply system.[12]

During March 1944, General Arnold paid a visit to the Kansas area. He came away with a bad impression of the situation he found there. The confusion of the overlapping activities, staging, modification and training, not to mention the production line changes which continued to complicate the supply problem, served to create an unfortunate picture. Foul winter weather brought even greater discouragement to the program.[13] General Arnold, however, ordered emergency treatment to guarantee that the B-29 program would head for combat at the scheduled time. There began a period known as the "Blitz". Supply and other personnel worked sixteen hour stretches for days on end. Individual work sheets for each airplane were drawn up by the Air Service Command to record the status of completion, the missing critical parts, and every factor which promised to delay the departure date.

The PQ project became a personal problem. Each airplane was treated as if it were a veritable squadron about to depart for overseas. Each airplane was nursed up to the point of complete readiness, and by early April 1944, the Superfortresses of the 58th Wing departed for combat.[14]

The success of the informal committee working in conjunction with the field installations during the period leading up to the departure of the 58th Wing led to the decision to retain

and enlarge the group. The B-29 Supply Committee, as it came to be known, was a functional body, pragmatic in its approach. Policies and procedures which were found to be unworkable or cumbersome were rejected immediately, and every detail of the supply technique was streamlined for the highest efficiency.

This teamwork in expediting supply was made possible by meetings held three times weekly with representatives of the Aircraft, Equipment, and Signal Sections as well as other Supply Sections concerned. The B-29 Maintenance Project Officer, Captain M.C. Villiard, also attended the meetings and coordinated special maintenance problems. Lieutenant Colonel L.A. Shelton, the Committee Chairman, Major George Kahn and Major W.L. Frisk served on the committee continuously from its origin in October 1943, but membership from the ten or twelve sections represented varied from time to time.

With the completion of the PQ project for the 58th Wing, a whole series of similar projects had to be undertaken to supply the Twenty-First Bomber Command. This program consisted of the following projects:

QQ for the 73rd Wing
RQ for the 313th Wing
SZA for the 314th Wing
SZB for the 315th Wing

The B-29 Supply Committee, established originally to coordinate all supply activities in connection with the B-29 project, became an expediting group processing normal provisioning as well as special requests from the combat theaters. As changed conditions in the field raised new problems, the Committee

revised procedures to suit the occasion. To insure a high standard of reality in its operation, the Committee welcomed visitors from both domestic and combat theater installations at the thrice weekly meetings where all B-29 supply policy matters, with the exception of the broadest questions referred to the Chief and Deputy Chief of the Supply Division, Major General L.T. Miller and Colonel W.D. Dana, were hammered out.[15]

Priority methods were used where necessary, but as the number of wings increased and experience revealed the most satisfactory supply methods, procedures gradually became more standardized. By October 1944 a comparatively formal system had been established.

The Air Technical Service Command B-29 Committee was to control all B-29 supply activities in the United States with Control Depots at Oklahoma City, San Antonio, and Mobile Air Technical Service Commands performing maintenance and stocking parts. This procedure considerably widened the base of B-29 supply activities, for previous to October 1944 only Oklahoma City Air Technical Service Command and certain Specialized Depots had handled B-29 parts.

To make the new organization work smoothly, San Antonio and Mobile sent personnel to Oklahoma City to familiarize themselves with the accepted B-29 procedures. Each of the three Control Depots was to supply the various B-29 air bases within its jurisdiction as well as those in geographical proximity but technically in areas of Control Depots not designated as B-29 supply units.[16]

To reduce the supply problem as much as possible, all B-29 using agencies, Depots, Sub-Depots, and air bases, were encouraged to rely upon a system of local manufacture for relatively simple parts which could be produced without great difficulty on existing tools. This practice was encouraged and simplified by the circulation of manufacturers' blueprints on microfilm and a special Technical Order designating items suitable for local fabrication.[17]

Wherever possible, the B-29 was placed in the normal channels of supply, but priority or emergency problems were given "Blue Streak" treatment.[18] The Blue Streak procedure, a high pressure method of filling urgent supply requests for domestic bases, consisted of wire or telephone reports to Headquarters, Air Technical Service Command, with 48-hour service to fill the need. When the Aircraft Section of the Supply Division accepted a Blue Streak request, the part was located in a Control or Specialized Depot and dispatched to the point of need. By such methods the number of aircraft grounded for parts has been reduced to an almost insignificant minimum.[19]

Overseas high priority supply requests were handled in a somewhat similar manner. All Twenty and Twenty-First Bomber Command requisitions for replacement parts to use in AOCP cases, that is, airplanes actually grounded for want of parts or in anticipation of such emergencies, were handled by "Emergency Requests" through the Pacific Overseas Air Technical Service Command at Oakland, California, which extracted the materials from the Specialized Depots and Control Depots without delay.[20]

Because of the complexity of supply resulting from engineering changes in the successive blocks of production airplanes, requisitions for parts were processed on the basis of individual aircraft serial numbers to be certain that the replacement part shipped would be suited to the particular model and block represented by the grounded airplane.[21] Shipments on "Emergency Requests" were arbitrarily limited to one quarter of the total stock on hand because of the danger of accumulating excessive stocks at specific operational bases at the expense of adequate reserves to meet subsequent general requests.

In cases of particular necessity, B-29 parts manufacturers handled "Emergency Requests" directly from production line output with no greater authority than the emergency request itself. However, when the requisition exceeded the equivalent of ten production airplanes, it was screened by Headquarters, Air Technical Service Command. Emergency requests for the Marianas ferry route were handled in the same way as combat theater requests.[22]

Such an involved and intricate system of supply necessarily required an efficient system of control. To record and follow up individual shipments, Headquarters, Air Technical Service Command, introduced Statistical Control Office methods which have been an important factor in the success of the entire system of B-29 overseas supply.

Beginning March 1944, the Statistical Control Office, at the request of the Supply Division, established a punch-card IBM

control for B-29 parts which recorded the progress and status of every individual item of supply in the B-29 project. By maintaining a status record of all parts, the task of assembling organizational equipment for outfits moving overseas was reduced to the simplest terms. Moreover, combat theater requests could be controlled in minute detail from actual receipt of request, through the processing phase at the Pacific Overseas Air Technical Service Command and final shipment through Intransit Depots.[23]

The long range planning, enthusiastic personal response to emergency requests, and fundamentally sound procedures of the B-29 supply system paid off rewardingly in March 1945. The Twenty-First Bomber Command reported that the average time between "Emergency Request" by the theatre and actual receipt of critical items in the theatre had been reduced to 6.1 days. More impressive still, perhaps, was the combat record in the Marianas. After three days of maximum strikes against Japan only 1.7% of all B-29's in the Marianas were grounded for parts and one day later not a single airplane remained unable to fly because of a missing part, an achievement eliciting the praise of Major General B.E. Meyers, Deputy Director of the Air Technical Service Command: "This is a remarkable attainment reflecting great credit not only on the Supply Division of this Headquarters, but on the Command as a whole."

THE MAINTENANCE PHASE

During the early period of organization of the 58th Wing, it was the opinion of the officers of that organization that the potential long range operating radius of the B-29 would make it unnecessary to plan conventional maintenance establishments for servicing the new airplane. It was contemplated that shuttle flights from Alaskan to Indian or Chinese bases would obviate the normal chain of ferry and operational bases used in distant theaters with all previous aircraft.

The plan was known as the "live-off-the-land" theory. Entire crews, officers and enlisted men, were to be trained in maintenance and tools necessary for lower echelon maintenance and repairs were to be carried in the airplane itself in special tool cribs. It was further assumed that such higher echelon maintenance as would be necessary could be done at existing friendly bases. Needless to say, this plan never emerged from the theory stage. The B-29 turned out to be one of the most complicated of all airplanes in the matter of maintenance.[1]

To begin with, the sheer size of the B-29 made it a unique problem. Tools and equipment which were satisfactory for other four engine bombers were dwarfed by B-29 requirements. Moreover, the B-29 went into the field before it had fairly emerged from the experimental period. Difficulties which normally would have been ironed out in the testing period remained in early production models and greatly increased the burden of field maintenance. The fact that the Central Fire Control System and

the electrically driven accessories as well as the cabin pressurizing system were all novel systems only served to complicate the maintenance problem.

The extreme urgency of the B-29 requirement -- the fact that the airplanes were committed to an early appearance in the combat theaters -- not only foreshortened the Service Test period but telescoped every successive phase as well. The Superforts went directly from the factory to the Cornbelt, where staging, modification, and training were performed all at once.[2] The novelty of the type made intensive training an absolute necessity. Furthermore, because the combat theater commitment date made production line changes impossible, the time element made large scale maintenance modifications essential. Every factor seemed to conspire to increase the burden of maintenance difficulties.

In January 1944 MM&D assigned a project involving modification of planes for the 58th Wing to the Air Service Command. Originally the plan called for 137 airplanes to be ready by the deadline date 1 March 1944. By April this number had been increased, and 164 airplanes had actually been modified and delivered.[3]

Modifications for the PQ project, as it was designated, touched a number of critical items. Three additional tanks were built into the forward bomb bay. Also kits were prepared for the installation in the theater, where necessary, of three extra tanks in the rear bomb bay. Subsequently, upon the request of the 58th Wing, defueling units were produced and

shipped to the theater to empty the six-tank assembly for the purpose of speeding up deliveries of fuel to forward bases.

Other important modifications included the installation of slings and dollies in the rear bomb bay to carry a spare engine (called a "pin-up") to the theater in the plane itself. Installations of AN/APQ-13 radar equipment were performed at the Oklahoma City and San Antonio Air Service Commands while field installations were handled by personnel from the Warner-Robins Air Service Command. Perhaps the most interesting modification was the engine change made immediately prior to departure for overseas when "training" engines were replaced with "combat" engines.[4] Every engine which had logged more than 75 hours was removed, reconditioned, and installed on new airplanes destined for training purposes.[5]

When operational experience by the 58th Wing in the combat theater revealed that modifications were necessary, the Air Service Command Maintenance Division prepared kits and instructions for a large number of items such as foot-operated microphone switches, antenna clean-ups, AN/ART-13 auto-tuning control transmitters, SCR-522 VHF radio units, turbo-supercharger pressurization kits for AN/APQ-13 radar units as well as AN/APQ-4 long range navigation apparatus.[6]

Finally, as a maintenance service deluxe, C-46 airplanes were especially equipped with machines, hand tools, and small spares to be used in the combat area for emergency repairs whenever B-29's were forced down at remote landing strips. Thus, the Maintenance Division laid the ground work for a global repair shop.[7]

The project for the 73rd Wing, nucleus of the Twenty-First Bomber Command, brought further problems to the Maintenance Division. Outstanding among the modifications were those concerned with engine cooling. When operational flying in high temperature areas aggravated engine cooling difficulties, ducted engine baffles were installed to improve twin row cylinder cooling. Cross-over tubes providing a more adequate flow of cylinder oil to valves further improved engine cooling. Modifications to the cowl flaps permitted accurate adjustment to compensate for changes in engine temperature caused by variations in altitude and power settings.

Not all project modifications were directed at engine cooling, however. Installation of detachable ball joints on forward exhaust collector rings made it possible to replace individual ball joints without the necessity of replacing the entire forward assembly. Snap-opening actuating mechanisms for bomb bay doors overcame the serious opening lag in the earliest production airplanes.[8] The latter modification did not become standard because a completely redesigned pneumatic door later appeared on the production line.

In all, a total of 330 airplanes were modified in the engine cooling project at the cost of approximately 600,000 man-hours. This expenditure of effort, extending from August 1944 to January 1945, probably illustrates the activity of the Maintenance Division more graphically than any other index.[9] These modifications by Maintenance Division personnel must not be confused with the work of commercially operated modification

centers, which were entirely separate contract operations piling up an even greater number of man-hours on all types of airplanes.

Among the most interesting modifications of the entire B-29 project was the 315th Wing "Eagle Modification". This involved stripping B-29's of the major part of their normal armament load, an important weight saving because each gun position omitted meant not only less turret weight but saved the gunner's weight as well. The stripped airplanes were then equipped with AN/APQ-7 or Eagle radar equipment, which provided a sharp radar scanning scope. The purpose of this modification was to permit the airplanes to fly higher and faster than had been possible with the added weight and at the same time to increase the accuracy of bombing with the aid of an additional radar device attached to the Norden bombsight, a combined apparatus called "Eagleeagle".[10]

The airplanes were stripped at the Bell Marietta facility and flown to Oklahoma City, where the new radar installations were made. The project, an A-1 priority enterprise, contemplated modifying 143 airplanes, beginning in February 1945, after which modification centers and production lines were to absorb the change.[11]

In addition, to release as many B-29's for combat as possible, various features of the B-29, such as the Central Fire Control System, were installed in B-24's used for training purposes.

One of the most telling proofs of the fact that the Superfortress has come of age is the fact that war weary B-29's have already been returned from combat. To adapt these war weary

airplanes to training purposes, the Maintenance Division undertook a recovery project, DOM 594. This project turned out to be a large scale activity. The returned airplanes represented a wide cross section of production articles with every combination of modification and state of design change present. Recovery became virtually a custom job for each airplane. Long overdue Technical Order compliances had to be brought up to date, flak holes had to be sealed to restore pressure cabins to effective use, while emergency methods had to be accepted where field modifications made normal procedures impossible.[12]

The first eleven war weary airplanes were made ready for use as training planes only after the expenditure of 20,000 man-hours for each airplane. Increasing skill in tackling this particular job reduced the burden to 15,000 man-hours per airplane, but the cost in labor hours at that figure is still sufficiently great to indicate the difficulties encountered by the Maintenance Division.[13]

At San Antonio Air Technical Service Command, where the work is being accomplished, the Maintenance Division estimate a total of 230,000 man-hours available each month for all maintenance operations, but the war weary B-29 recovery project promise to consume approximately 1,215,000 man-hours by itself.[14]

In the ordinary course of events, ground equipment to service airplanes is perfected by the Experimental Engineering Section, procured by contract, and distributed by supply, but the urgency of the B-29 project telescoped the normal development period to the point where B-29's had become operational

before all the special servicing equipment their extraordinary size required could be developed. Inevitably the service squadrons in the field fabricated makeshift arrangements to fill the need, and the Maintenance Division took emergency steps to supplement the ingenuity of field service personnel.

The Twenty-First Bomber Command crew-chief stand was an example of the type of equipment perfected by the Maintenance Division. Theater reports revealed that line crews were making work stands from any available material, Japanese rail iron, quonset hut assemblies, and tank bogie wheels.[15] The Maintenance Division secured photographs and rough drawings of these field-made stands, issued contracts in January 1945 for delivery, beginning in April, to the theater by Red Ball Engine boat. The Maintenance Division set out to overcome the incongruity of millions of dollars invested in airplanes being wasted for want of adequate equipment to perform routine maintenance functions.[16]

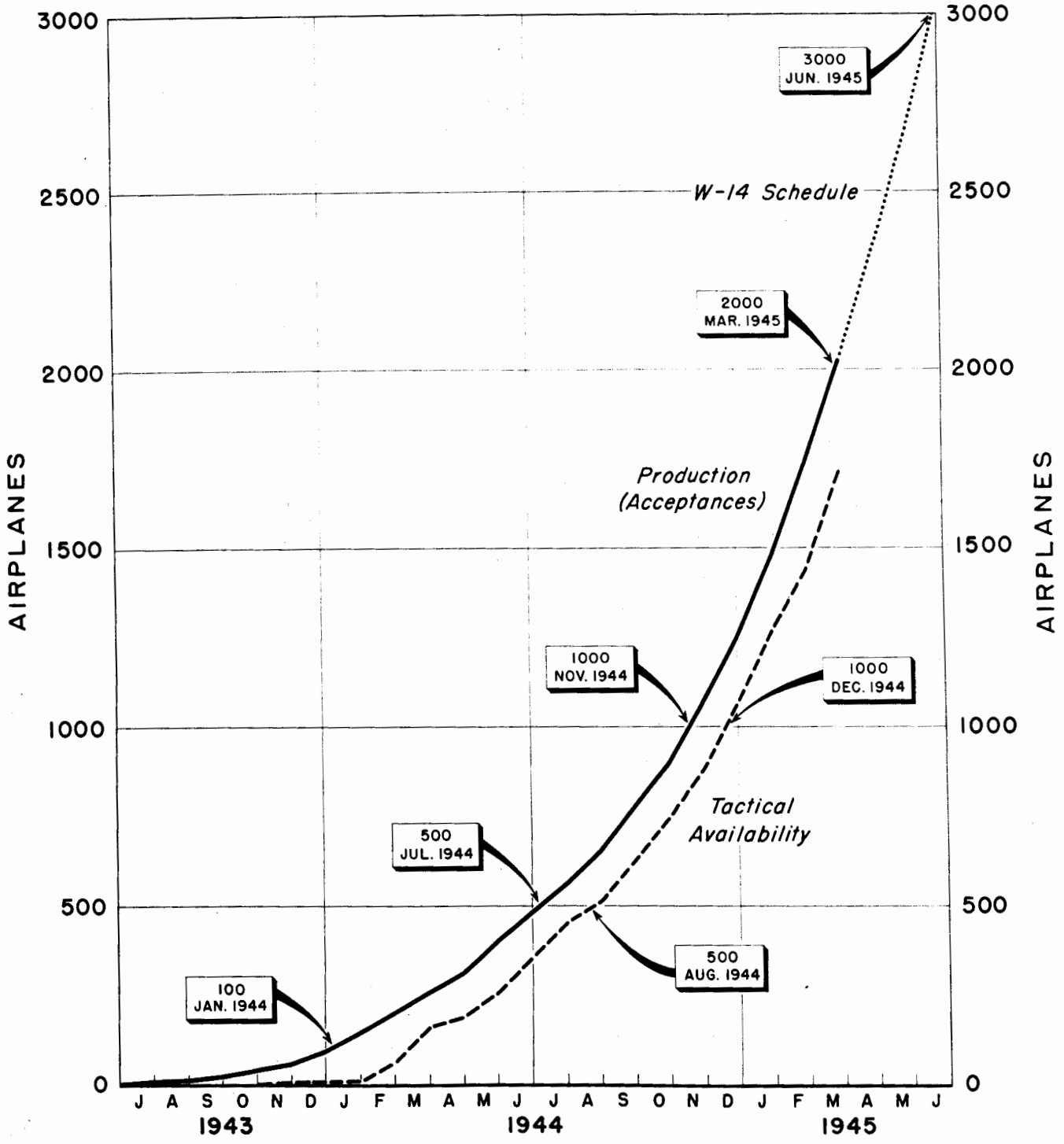
An outstanding Maintenance Division short cut to speed field servicing in B-29 units was the emergency power unit. Turret synchronization and landing gear retraction tests on the ground required high capacity portable electrical power plants for use during periods when it was impractical to run the airplane engines. Existing portable-generator equipment did not supply adequate power, and production of a new model would consume many valuable months. To deliver the current needed with the least delay, the Maintenance Division decided to modify arc welders from existing AAF stock supplies. A simple modification,

installation of a voltage regulator, and the addition of a set of pneumatic tires made it possible to ship 134 such units directly to air base units to overcome the critical situation.[17]

Another example of Maintenance Division enterprise appeared in connection with cabin-pressurization test equipment. When B-29's returned from missions damaged by flak it was necessary to devise some means of determining whether or not the pressure cabin remained air tight. Originally the only equipment available was complicated factory test equipment the size and weight of which prohibited its use in the field. By means of a remarkably simple venturi-principle tester, this complicated checking equipment was reduced to a matter of a comparatively few pounds.[18] Weight saving in ground equipment meant a reduction in vital loads to be ferried into the remotest airdromes and every pound saved in cargo weight meant more gasoline for increased range. Even at Headquarters Air Technical Service Command, it was possible to help the Army Air Forces "over the Hump".

CUMULATIVE B-29 OUTPUT

Production has accelerated steadily since the summer of 1944; a scheduled peak of around 400 more a month should be reached in 1945



Note:

Production includes 3 XB-29's accepted Dec. 1942

Tactical Availability includes F-13's – modified B-29's for photographic reconnaisance

THE TRAINING PHASE

Trained personnel to supply and maintain the bombardment groups of the 58th Wing in the theater of operations were necessary in both the supply and maintenance aspects of the B-29 program. In the normal course of events when a bombardment or fighter wing was formed, the Air Service Command was given the task of activating service support groups and supervising the various phases of organizational training which fitted them to serve a particular type of aircraft. The final phase of this operational training was conducted in conjunction with the tactical or combat units which the service groups would ultimately support in the field.

The Air Service Command anticipated that a directive to train service support groups for B-29 tactical organizations would be forthcoming from Headquarters Army Air Forces. Brigadier General E.E. Adler, Chief of the Personnel and Training Division, recognized the fact that it was essential to have service groups and air depot groups specially trained in the supply and repair problems peculiar to the B-29 particularly with regard to such equipment as central fire control, radar, pressurization, and the electronic control turbo-supercharger.[1]

At a B-29 training program conference held at Coloredo Springs in September 1943, General Adler raised the question of providing service support groups for the PQ project but was informed that such groups would be unnecessary in view of the "live-off-the-land" theory which contemplated using highly

trained combat crews and ground crews of the tactical organizations for specialized maintenance functions. General Adler insisted that it would be advisable to provide service and air depot groups to support the bombardment groups.

If it proved impossible to train supply and maintenance groups, General Adler was anxious to inaugurate a program to train a wide variety of individual specialists who in turn might be used to carry out a program of specialized B-29 training. Despite this opinion, the Air Service Command did not receive a training directive for either groups or individuals until as late as 12 November 1943, when verbal instructions were issued by the Assistant Chief of Air Staff for Training in Washington to prepare two service groups and one air depot group for overseas shipment with the B-29 project.

So much time had elapsed since the necessity for executing such a plan had been recognized that General Adler immediately called a conference of Military Training and Operations Section and Military Personnel Section representatives to plan the B-29 training program. The Maintenance Division recommendations covering the requirements for specialized training within these B-29 support groups and the addition of several specialists not included in the normal Table of Organization for service and air depot groups were reviewed as a working basis in the proposed program. Chief among the additional personnel recommended were the ten officers and sixteen enlisted men as fire control system specialists in air depot groups and one officer and seven enlisted men for a similar function in each service squadron.[2]

To insure a high standard of coordination in all matters concerning the B-29 training project, General Adler appointed Lieutenant Colonel Dallas M. Spear as B-29 Project Officer for the Personnel and Training Division. Thus, by November 1943 all the Divisions of Air Service Command had appointed special B-29 project officers.

The 25th and 28th Service Groups and the 22nd Air Depot Group, already in training at the time, were diverted from their original objectives and selected as B-29 units for the PQ project. To train the necessary additional fire control technicians, a special training course was organized at Lowry Field, Denver, Colorado.[3]

As soon as the three groups had been earmarked for B-29 training, every effort was made to expedite them for overseas shipment in order to guarantee their arrival in the theater of operations before the bombardment groups left for India. The first detachment of the 22nd Air Depot Group left the United States in January 1944 and the first units of the 28th Service Group left at about the same time. Maintenance specialists who had remained behind to complete their specialized training were later flown to the theater in the B-29's of the 58th Wing.[4]

Preparations for the Twenty-First Bomber Command were less hurried; in contrast to groups sent overseas for the 58th Wing in which only certain specialists received B-29 training, succeeding support groups for the Twenty-First Bomber Command received

combined training in conjunction with the B-29 bombardment groups that they were to service in the field.[5]

The combined training program was carried out in the midwestern B-29 training area where the combat crews were undergoing their final period of instruction. After the initial basic and unit training phases had been accomplished at Warner-Robins Air Service Command and San Antonio Air Service Command, as well as Fresno Replacement Center, the air depot and service groups were moved to the Oklahoma City area where they acquired a wide range of practical experience in meeting actual problems of supply and repair under field conditions. Supply unit trainees, for example, worked in Air Force supply organizations operating supply facilities of the same or approximate level they would be expected to operate in the field.

The specialized education of supply personnel was considerably enhanced by the instruction received in the use of the Boeing Spares Document. Experience had shown that a sound knowledge of the use of the spare parts document would do much to simplify and expedite the difficult procedure of ordering spares from higher supply echelons and prevent many mistakes which might be committed in the field.[6]

Similarly, maintenance personnel, particularly those specialists in fire control equipment and fuel injection systems who required training beyond their initial technical instruction, were provided "live" problems to solve. Specialists in the R-3350 engine received a wealth of field experience while still under the supervision of the training center technicians.

Large numbers of B-29 project trainees were interviewed and those with peculiarly well qualified technical backgrounds were assigned to the modification assembly line of the Oklahoma City Air Technical Service Command described in a previous section.[7] This utilization of enlisted men from support groups in modification and engine overhaul work served a dual purpose. Not only did the men acquire an intimate knowledge of the equipment to which they had been assigned, but the depots as well profited by the addition of valuable man-hours of skilled labor to accomplish the tremendous task of fitting the B-29's for combat.

Perhaps one of the most useful forms of "live" work the trainees received appeared whenever an infrequent B-29 crash occurred in the neighborhood of the training area. The air depot or service groups immediately dispatched a unit to the scene of the wreck to repair the airplane, if possible, or to salvage the recoverable spares.

The success of expeditions to recover crashed airplanes as a means of field training is attested by the performance of several such groups in salvaging five belly-landed B-29's. Sheet metal men, instrument and propeller specialists, armorers and engine specialists all joined in the recovery effort and in every case flew back to their home bases in the repaired airplanes.[8]

A brief resume of the organizations trained gives some idea of the extent of Air Technical Service Command training

activities. During 1944 and early 1945, six air depot groups and twenty-four service groups were trained to back up the bombardment groups which comprise the Twenty-First Bomber Command. In addition, two Aircraft Repair Units and two Aircraft Maintenance Units were trained and equipped to serve as mobile units operating on vessels which had been converted into maintenance and supply facilities for the B-29. The floating units were intended to serve until land based facilities could be erected on newly won island bases to replace them.[9]

The Repair Units operated on 10,800 ton Liberty Ships which had been completely equipped for third and fourth echelon repair work on airframe parts and accessories. One of the most important services of these "Floating Depots" was the ample supply of breathing oxygen for high altitude flight which the ships' oxygen plants were capable of producing. The floating Maintenance Units operated on considerably smaller ships and performed first, second, and third echelon work.[10]

In all, the Air Technical Service Command trained over 10,000 service organization personnel for the B-29 program, and of these a large proportion received technical training. Over 1500 enlisted men received training in factory schools in such specialized techniques as the maintenance of turbo-superchargers and the Wright R-3350 engine.[11]

The need for a centralized B-29 training school became evident as early as the beginning of 1944 when Air Service Command personnel attending the Boeing factory school in Seattle reported that instruction in third and fourth echelon repair

was inadequate.[12] To fill this need, the Civilian Training Branch at Oklahoma City Air Service Command was ordered to organize a B-29 familiarization school comprising fourteen basic courses varying in length from one to six weeks. Fuel injection and fire control systems, the most complex B-29 equipment items, were given particular prominence. By December 1944 over 670 persons, military and civilian, had graduated from the fuel injection course alone.[13]

The familiarization course was not limited entirely to military personnel. In addition to training service unit personnel, hundreds of civilian employees from Air Technical Service Command control depots as well as Second and Third Air Force depot employees, not to mention civilians from such private manufacturing concerns as American-Bosch, Dodge-Wright, and Bendix-Stromberg were trained in the school. This training made effective domestic maintenance of the B-29 possible. In all, a total of 1165 officers and enlisted personnel from twenty-four service, air depot, and special training groups have been given specialized instruction at the school in the period from September to December 1944.[14]

No other evolution of the B-29 personnel training program could be quite so revealing as the record from the field. The total number of missions completed by the Superforts is the best index of the training accomplished in the United States.

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